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Title:	METHOD AND APPARATUS FOR EFFICIENT CALCULATION AND USE OF RECONSTRUCTED PIXEL VARIANCE IN TOMOGRAPHY IMAGES

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APPEAL BRIEF PURSUANT TO 37 C.F.R. §§ 41.31 AND 41.37

This Appeal Brief is being filed in furtherance to the Notice of Appeal electronically filed on November 30, 2010.

The Commissioner is authorized to charge the requisite fee of $540.00, and any additional fees, which may be necessary to advance prosecution of the present application, to Account No. 07-0868.

1. REAL PARTY IN INTEREST

The real party in interest is General Electric Company, the Assignee of the above-referenced application by virtue of the Assignment to General Electric Company by Samit Kumar Basu, Bruno De Man, Peter Edic, Ricardo Avila, James Miller, Colin McCulloch, Deborah Walter, Paulo Mendonca, William Leue, and Thomas Sebastian, recorded at Reel 015164, Frame 0698, and dated March 31, 2004. Accordingly, General Electric Company, as the parent company of the Assignee of the above-referenced application, will be directly affected by the Board's decision in the pending appeal.

2. RELATED APPEALS AND INTERFERENCES

Appellants are unaware of any other appeals or interferences related to this Appeal. The undersigned is Appellants' legal representative in this Appeal.

3. STATUS OF CLAIMS

Claims 12-30 are currently pending, are currently under final rejection and, thus, are the subject of this Appeal. The Examiner rejected pending claim 29 under 35 U.S.C. §101. Claim 29 is independent. The Examiner rejected pending claims 12-30 under 35 U.S.C. §103(a). Of these, claims 12, 21, 28, 29 and 30 are independent. Also, claims 1-11 and 31-40 are withdrawn.

4. STATUS OF AMENDMENTS

In response to the Final Office Action mailed on August 30, 2010, Appellants had made minor amendments to the claims in the Appellants' response filed on November 1, 2010. Appellants note that the Examiner in the Advisory Action mailed on November 22, 2010 indicated that for the purposes of Appeal, the amendments had been entered. Consequently, there are no outstanding amendments to be considered by the Board.

5. **SUMMARY OF CLAIMED SUBJECT MATTER**

The present invention relates generally to image reconstruction in tomography systems. *See* Application, page 1, paragraph [0001], lines 1-2. More particularly, in certain embodiments, the invention relates to a method and apparatus for efficient calculation and use of reconstructed pixel variance data in tomography images. *See* Application, page 1, paragraph [0001], lines 2-3.

The Application contains five independent claims, namely, claims 12, 21, 28, 29 and 30, all of which are the subject of this Appeal. The subject matter of these claims is summarized below.

With regard to the aspect of the invention set forth in independent claim 12, discussions of the recited features of claim 12 can be found at least in the below cited locations of the specification and drawings. By way of example, an embodiment in accordance with the present invention relates to a method for generating a variance map from measured projection data acquired from a tomography system. *See e.g., id* at page 4, paragraph [0018], see also FIGs. 1-2, also *see* page 11, paragraph [0037] and FIGs. 6-9. The method includes accessing the measured projection data from the tomography system. *See e.g., id* at page 11, paragraphs [0037], [0040]-[0046] and FIGs. 6-7. Furthermore, the method includes formulating a variance measure based upon the measured projection data. *See e.g., id* at page 11, paragraphs [0037], pages 12-14, paragraphs [0040]-[0046] and FIGs. 6-7. In addition, the method includes generating the variance map from the variance measure using a reconstruction algorithm. *See e.g., id* at page 10, paragraph [0034], page 11, paragraphs [0037], pages 12-14, paragraphs [0040]-[0046] and FIGs. 6-7.

With regard to the aspect of the invention set forth in independent claim 21, discussions of the recited features of claim 21 can be found at least in the below cited locations of the specification and drawings. By way of example, an embodiment in

accordance with the present invention relates to a method for generating a variance map from measured projection data acquired from a tomography system. *See e.g., id* at page 4, paragraphs [0018], FIGs. 1-2, and FIGs. 6-9. The method includes accessing the measured projection data from the tomography system. *See e.g., id* at page 11, paragraphs [0037], [0040]-[0046] and FIGs. 6-7. In addition, the method includes formulating a variance measure based upon the measured projection data. *See e.g., id* at page 11, paragraphs [0037], pages 12-14, paragraphs [0040]-[0046] and FIGs. 6-7. The method also includes generating the variance map based upon the variance measure using a reconstruction algorithm. *See e.g., id* at page 10, paragraph [0034], page 11, paragraphs [0037], pages 12-14, paragraphs [0040]-[0046], pages 14-15, paragraphs [0047]-[0049], and FIGs. 6-8. Moreover, the method includes displaying, analyzing or processing the variance map. *See e.g., id* at page 11, paragraphs [0037], page 14, paragraph [0046], pages 14-15, paragraphs [0047]-[0049], pages 16-17, paragraph [0050] and FIGs. 6-9.

With regard to the aspect of the invention set forth in independent claim 28, discussions of the recited features of claim 28 can be found at least in the below cited locations of the specification and drawings. By way of example, an embodiment in accordance with the present invention relates to a tomography system (item 10) for generating a variance map from measured projection data. *See e.g., id* at page 4, paragraphs [0018], FIGs. 1-2, and FIGs. 6-9. The system includes an X-ray source (item 12) configured to project a plurality of X-ray beams (item 18) through an object (item 18). *See e.g., id* at page 4, paragraphs [0019], FIGs. 1-2. Additionally, the system includes a detector (item 22) configured to produce a plurality of electrical signals in response to received X-ray beams from the source. *See e.g., id* at page 4, paragraphs [0018], FIGs. 1-2, and FIGs. 6-9. The system also includes a processor (item 36) configured to process the plurality of electrical signals to generate measured projection data, wherein the processor is further configured to access the measured projection data from the tomography system, to formulate a variance measure based upon the measured projection data, to generate a variance map based upon the variance measure using a

reconstruction algorithm, and to display, analyze or process the variance map. *See e.g., id* at page 4, paragraphs [0018], page 8, paragraph [0029], FIGs. 1-2, and FIGs. 6-9.

With regard to the aspect of the invention set forth in independent claim 29, discussions of the recited features of claim 29 can be found at least in the below cited locations of the specification and drawings. By way of example, an embodiment in accordance with the present invention relates to at least one non-transitory computer-readable medium storing computer instructions for instructing a computer system for generating a variance map from projection data acquired from a tomography system. The computer instructions include accessing the projection data from the tomography system, generating a variance map from the projection data, and displaying, analyzing or processing the variance map. *See e.g., id* at page 21, paragraphs [0062], FIGs. 1-2, and FIGs. 6-9.

With regard to the aspect of the invention set forth in independent claim 30, discussions of the recited features of claim 30 can be found at least in the below cited locations of the specification and drawings. By way of example, an embodiment in accordance with the present invention relates to a tomography system (item 10) for generating a variance map from measured projection data. *See e.g., id* at page 4, paragraphs [0018], FIGs. 1-2, and FIGs. 6-9. The system includes means for accessing the measured projection data from the tomography system. *See e.g., id* at page 4, paragraphs [0018], page 8, paragraph [0029], FIGs. 1-2, and FIGs. 6-9. In addition, the system includes means for formulating a variance measure based upon the measured projection data. *See e.g., id* at page 4, paragraphs [0018], page 8, paragraph [0029], FIGs. 1-2, and FIGs. 6-9. The system also includes means for generating the variance map based upon the variance measure using a reconstruction algorithm. *See e.g., id* at page 4, paragraphs [0018], page 8, paragraph [0029], FIGs. 1-2, and FIGs. 6-9. Furthermore, the system includes means (item 42) for displaying analyzing or processing the variance map. *See e.g., id* at page 6, paragraphs [0025], FIGs. 1-2, and FIGs. 6-9.

A benefit of the invention, as recited in these claims, resides in a technique for the efficient generation of variance data and variance maps to provide additional information about measured projection data and reconstructed images useful for analysis and, in the medical context, diagnosis. In addition, the technique for generation of the variance map is computationally efficient because changing of the weighting factors and squaring the filter impulse response steps using the weighted filtered backprojection reconstruction algorithm in accordance with the present technique, may be performed offline, resulting in no change in the computational cost of the process of generating the variance map. Moreover, the variance measure may be computed in the same number of operations it takes to compute the mean pixel value. In particular, the generation of the variance map in accordance with the present technique does not require any additional measurements to determine the variance measure. Furthermore, the present technique may be applied to CT reconstruction algorithms from any geometry, such as for example, 2D, 3D, 4D, axial, helical, cone beam, and so forth. Also, the generation of the variance maps in accordance with the present technique is directly applicable to any generation or type of CT imaging system. Additionally, the variance maps generated in accordance with the present technique may also be generated from other tomographic systems, such as, for example, PET, SPECT, MRI, etc. The variance maps generated in accordance with the present technique may also be generated from other tomographic and non-tomographic imaging modalities such as for example, MR, US, optical, EIT, X-ray etc.

6. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

First Issue for Review on Appeal:

Appellants respectfully urge the Board to review and reverse the Examiner's ground of rejection in which the Examiner rejected claim 29 under 35 U.S.C. §101 because the claimed invention is directed to non-statutory subject matter. Appellants respectfully traverse the rejection of claim 29.

Rejected claim 29 is independent and will be discussed in detail below.

Second Issue for Review on Appeal:

Appellants respectfully urge the Board to review and reverse the Examiner's ground of rejection in which the Examiner rejected claims 12-30 under 35 U.S.C. §103(a) as being unpatentable over Shih et al., (U.S. Patent Application No. 2005/0152504, hereinafter "Shih") in view of Liang et al., (U.S. Patent No. 7,187,794, hereinafter "Liang"). Appellants respectfully traverse the rejection of claims 12-30.

Rejected claims 12, 21, 28, 29 and 30 are independent and will be discussed in detail below.

7. ARGUMENT

As discussed in detail below, the Examiner has improperly rejected the pending claims. Further, the Examiner has misapplied long-standing and binding legal precedents and principles in rejecting the claims under Sections 101 and 103. Accordingly, Appellants respectfully request full and favorable consideration by the Board, and reversal of the outstanding rejections. Appellants strongly believe that claims 12-30 are currently in condition for allowance.

A. **<u>Ground of Rejection No. 1</u>:**

The Examiner rejected claim 29 under 35 U.S.C. §101 because the claimed invention is directed to non-statutory subject matter. The Examiner noted that while claim 29 defines a "computer readable medium" embodying functional descriptive material, it does not define a non-transitory computer-readable medium or memory and is thus non-statutory for that reason. Of the remaining pending claims, rejected claim 29 is independent and will be discussed in detail below. Appellants respectfully assert that the present invention as recited in independent claim 29 is patentable. Hence, Appellants respectfully traverse the rejection of claim 29.

<u>Claim 29</u>

Appellants submit that independent claim 29 recites at least one non-transitory computer-readable medium storing computer instructions for instructing a computer system for generating a variance map from projection data acquired from a tomography system, the computer instructions including accessing the projection data from the tomography system, generating a variance map from the projection data, and displaying, analyzing or processing the variance map.

Regarding claim 29, the Examiner suggested amending claim 29 to embody the program on a "non-transitory computer readable medium" to the claim or equivalent in order to make the claim statutory. In the response filed on November 1, 2010, Appellants amended claim 29 to include the recitation of "non-transitory" in the claim. No new matter is added. In the Advisory action mailed on November 22, 2010, the Examiner indicated that for the purposes of Appeal, the amendment of claims proposed in the response filed on November 1, 2010 have been entered.

In light of this amendment and the Examiner's indication of entering the proposed amendment, Appellants believe that the Examiner's rejection of claim 29 is overcome.

Accordingly, Appellants respectfully request that the rejection of claim 29 under 35 U.S.C. §101 be withdrawn.

B. **<u>Ground of Rejection No. 2</u>:**

The Examiner rejected claims 12-30 35 U.S.C. §103(a) under 35 U.S.C. §103(a) as being unpatentable over Shih et al., (U.S. Patent Application No. 2005/0152504, hereinafter "Shih") in view of Liang et al., (U.S. Patent No. 7,187,794, hereinafter "Liang"). Of the remaining pending claims, rejected claims 12, 21, 28, 29 and 30 are independent and will be discussed in detail below. Appellants respectfully assert that the present invention as recited in independent claims 12, 21, 28, 29 and 30 are patentable over the Shih reference in view of the Liang reference. Hence, Appellants respectfully traverse the rejection of claims 12-30.

Obviousness cannot be established absent a teaching or suggestion in the prior art to produce the claimed invention. For a *prima facie* case of obviousness, the Examiner must set forth the differences in the claim over the applied references, set forth the proposed modification of the references, which would be necessary to arrive at the claimed subject matter, and explain why the proposed modification would be obvious. It is well-established law that the mere fact that references may be combined or modified does not render the resultant modification or combination obvious unless the prior art suggests the desirability of the modification or combination.

Appellants respectfully submit that independent claims 12, 21, 28, 29 and 30 recite, in generally similar language, *methods and systems for <u>generating a variance map from measured projection data</u> acquired from a tomography system.* More particularly, measured projection data is accessed from the tomography system, *<u>a variance measure is formulated based upon the measured projection data</u>* and *<u>the variance map is generated from the variance measure</u> using a reconstruction algorithm.*

Appellants submit that the present application is drawn to methods and systems for generating a variance map from measured projection data acquired from a tomography system and for displaying a variance map to permit display and analysis of the images (for example, see FIGs. 1-5). In particular, as disclosed in the present application, measured projection data is acquired using a tomography system and stored (see steps 90 and 92 of FIG. 6). The projection data includes measured projection data. However, the projection data may also include simulated projection data or reconstructed image data. By way of example, at step 90, the measured projection data is acquired by the computed tomography system 10 (see FIG. 1). Also, at step 92, the measured projection data is stored in the memory 38 (see FIG. 1), for example.

Moreover, the measured projection data is accessed for processing to identify variances in the pixel data (see step 94 of FIG. 6). Specifically, in one embodiment, the processing includes generating variance data. Additionally, where desired, a variance map is generated from the measured projection data (see step 96 of FIG. 6).

Furthermore, as disclosed in the present application, a variance measure is formulated based upon the measured projection data (see step 102 of FIG. 7). Particularly, the variance measure is formulated or computed by replacing the measured projection data by an estimate of the signal variance. By way of example, in case of X-ray CT, the estimate of the signal variance is determined by assuming that the measured projection data are Poisson random variables. However, in case of high count rate CT, the estimate of the signal variance is determined by assuming that the measured projection data is normally distributed with a standard deviation equal to the square root of the mean.

Subsequently, a standard deviation measure is formulated based upon the measured projection data using a statistical model (see step 104 of FIG. 7). Additionally, other sources of noise or measures of uncertainty due to other physical effects may be modeled and calculated from the measured projection data (see step 106 of FIG. 7). One such measure of uncertainty, for example, may be based upon the path length or integrated

attenuation associated with the measured projection data. Moreover, the variance measure is computed from the standard deviation measure (for example, see equation (3) of the present application). It may be noted that the measured projection data that is input into the statistical model is offset corrected and normalized, before taking the logarithmic value, in one embodiment. Furthermore, some other examples of noise processes that may be incorporated into step 106 include models for electronic noise in the data acquisition system, and quantization errors that arise from analog to digital conversion. Processing the measured projection data as described hereinabove aids in establishing a statistical relationship and statistical model between the measured projection data and the estimate of the variance measure associated with the measured projection data.

Also, in one embodiment, a weighted filtered backprojection reconstruction algorithm is used to operate on the variance data to generate the variance map (see step 110 of FIG. 7, also see FIG. 8). Particularly, the variance measure based upon the measured projection data obtained by a statistical model (see equation (1) of the present application) is processed by an analytical technique. By way of example, in one embodiment, the technique includes a series of weighting, filtering and backprojection steps to generate the variance map, in a process known as weighted filtered backprojection (WFBP) (see FIG. 8).

The generation of the variance map using a WFBP algorithm, one embodiment entails application of the squared weights to the variance measures (see step 112 of FIG. 8). For example, in the weighting step of the WFBP algorithm, each variance measure is weighted by a factor of $w*w$ (where w refers to the weighting in the original WFBP algorithm). Also, responses of the variance measures to a squared filter are applied (see step 114 of FIG. 8). For example, the filter responses are squared, wherein each variance measure is convolved with the square of the sequence or impulse response, that is, $h(n)*h(n)$ (where $h(n)$ refers to the impulse response). Moreover, backprojection is applied to the variance measures (see step 116 of FIG. 8). Here again, by way of example, each pixel variance measure is updated with a detector value multiplied by the square of the weight used in regular backprojection. Particularly, in fan beam backprojection for WFBP, the

update includes dividing by a factor of L^4, where L is the distance from the pixel to the X-ray source.

Consequent to the processing by steps 112, 114 and 116 of FIG. 8, a variance map that includes pixel variances is generated. It may be noted that since the variance map tends to be smoother than the original image data, fast algorithms for backprojection/reconstruction may be used with a lower impact on overall quality.

The variance may be displayed, analyzed and processed based on the original image data (see step 98 of FIG. 6. In particular, the measured projection data is reconstructed to generate original image data 70 (see FIG. 3, also see step 118 of FIG. 9). Subsequently, the variance map generated in step 96 of FIG. 6 is displayed, analyzed or processed based upon the original image data 70 (for example, see FIG. 4) (see step 120 of FIG. 9). The variance map generated in accordance with the present technique provides visual cues to the high noise regions in the reconstructed image. In addition, the variance map may be used to provide for improved accuracy in computer aided detection (CAD) and classification algorithms that utilize variance information. The information may be used to adapt such CAD techniques for specific use of the variance data, such as by adjusting sensitivity, confidence, or other parameters employed by the algorithms. Also, the data provides for visual cues to aid in the identification of image features that may result from or that may be affected by structured noise as opposed to object structure/anatomy.

Moreover, measured projection data may be reacquired based upon the variance data computed (see step 100 of FIG. 6). Such reacquisition may be useful for adapting a subsequent acquisition sequence by altering the acquisition system settings based upon the variance map. For example, a subsequent acquisition may be performed at a higher dosage to permit an enhanced image to be reconstructed with greater analytical or clinical value. The present technique thus greatly facilitates the analysis process by permitting rapid analysis of the reliability of image data and reacquisition, where appropriate, obviating the need to schedule a second, subsequent imaging session.

The variance map so generated provides visual cues to the high noise regions in the reconstructed image. Additionally, the variance may also be used to provide for improved accuracy in computer aided detection and classification algorithms that utilize variance information. Furthermore, as described on page 10, paragraph [0033] of the present application, the present application teaches “an efficient approach for processing measured data and for generating variance data from measured projection image data.”

Appellants further submit that the variance data computed as summarized hereinabove may be used and visualized in many ways. For example, the variance data may be mapped as shown in FIG.. 4 to provide an indication of image data quality and reliability. Such visualizations may be entirely separate from displays of the corresponding reconstructed image. Alternatively, the map may be simply overlaid with the reconstructed image, or used to alter the image in any desired respect. By way of example, the relative values of the variance may be used to alter each pixel of the reconstructed image, such as by changing the hue saturation and value to reflect the relative variance of each pixel in the image. Furthermore, a user viewing the combined image is thereby alerted to the relative reliability of the image data in light of the variances of the pixel data.

In the Office Action mailed on August 30, 2010, the Examiner argued that Shih teaches a method for generating a variance map from measured projection data acquired from a tomography system comprising: accessing the measure projection data from the tomography system (citing A tomography system 100 comprises an imaging system 102 and noting that FIG. 3 of Shih teaches acquiring an object projection of an object 310); formulating a variance measure based upon the measured projection data (citing paragraph [0010] of Shih, generating the variance reconstruction from the variance projections) and generating a variance map from the variance measure using a reconstruction algorithm (citing paragraph [0043] of Shih, the variance projection includes an intensity map and positional data for the perspective that is common to the standard and object projections, and

noting that 3D variance reconstruction of the variations between the object and the standard is generated, and the object is qualified based on the variance reconstruction).

Furthermore, in the Advisory Action mailed on November 22, 2010, the Examiner argued that Shih teaches variance projections of the variations between the object and standard projections (citing same object) for particular perspectives are generated. The Examiner noted that variant portions of the variance projections are identified and used to generate a 3D reconstruction of just the variations between the object and the standard. Further, the Examiner noted that the 3D reconstruction can be evaluated to qualify the object (citing the Shih Abstract). The Examiner also noted that Shih clearly teaches (citing paragraph [0045]) that the standard projection can be considered the measured projection where graphical user interface can provide variance data to the operator. The Examiner further noted that a graphics generator of the numerical analyzer can superimpose the variance reconstruction of the variations over a stored 3D reconstruction of the standard to provide the operator with a visual indication of the differences between the object and the standard. Furthermore, the Examiner argued that the composite of the standard and variance reconstructions can be enhanced, for example through the use of colors or shading, to highlight defects for the operator.

Appellants, while disagreeing with the Examiner's position, note that in contrast to the present application, Shih is drawn to a method and apparatus for producing a variance reconstruction of variations between an object and a standard. In particular, Appellants assert that Shih presents a method of rapid automated inspection of manufactured objects that involves generating variance projections of the variations between the object and standard projections for particular perspectives (see Shih Abstract). Specifically, Shih is drawn to a method for producing a variance reconstruction of variations between an object and a standard that includes acquiring object projections of the object from a plurality of different perspectives, generating variance projections from the object projections by comparing the object projections with stored standard projections having corresponding perspectives, and generating the variance reconstruction from the variance projections.

Specifically, Appellants note that as disclosed in FIGs. 3 and 4 of Shih, a method 300 for qualifying an object includes a step of acquiring an object projection of an object (see step 310 of FIG. 3). Subsequently, a registration of the object projection relative to a standard projection is adjusted (see step 320 of FIG. 3). Furthermore, a variance projection from the object and standard projections is generated (see step 330 of FIG. 3). Also, variant portions of the variance projection are identified (see step 340 of FIG. 3). Moreover, it is determined whether the number of variance projections is sufficient to assess the quality of the object (see step 350 of FIG. 3). In addition, the object is qualified (see step 360 of FIG. 3).

Appellants submit that as disclosed at least in paragraph [0027] of Shih, the object projection of the object is acquired, at step 310 (see FIG. 3 of Shih). Clearly, as evidenced by Shih, <u>the object projection is a projection of the object that is acquired with a specific perspective</u>. Hence, the object projection includes a two-dimensional map of radiation intensity received at a detector and a set of positional data that define the perspective. By way of example, the object projection can be acquired, by placing a radiation source 502 on one side of the object 504 and a suitable detector 506 on the other side of the object 504 so that the detector 506 receives and records radiation transmitted through the object 504 (see FIG. 5 of Shih). Furthermore, the detector 506 is divided into an array of receptors, or pixel sensors, that each record the intensity of the incident radiation in a localized area. Also, in some embodiments, the pixel sensors convert incident radiation to an electric charge that can be measured and converted to a digital signal. The signal for each pixel sensor can be stored as a pixel of an intensity map component 508 of an object projection 510. For example, see paragraphs [0027]-[0028] of Shih.

With continuing reference to step 310 of Shih, Appellants note that in order to acquire an object projection of the object, image acquisition module 410 (see FIG. 4) determines a perspective for the object projection and communicates the perspective to a stage controller module 420 (see FIG. 4) that drives moveable components of the imaging

system, such as the stage, the radiation source, and the detector to their appropriate locations and orientations. For example, see paragraph [0031] of Shih.

Furthermore, at step 320, a registration of the object projection is adjusted relative to the standard projection. This adjustment of the registration corrects for minor variations between the positions of the object and the standard during the acquisitions of their respective projections. For example, see paragraph [0033] of Shih.

Also, at step 330, the variance projection is generated from the object and standard projections. As noted in Shih, <u>the variance projection represents the difference between the object and standard projections</u>. Further, the variance projection includes an intensity map and positional data for the perspective that is common to the standard and object projections. By way of example, if the object and the standard are essentially the same, and their respective projections were acquired under essentially the same conditions, then the intensity map component of the variance projection should be uniform and essentially equal to a baseline value such as zero. However, any differences between the object and the standard will be manifested as corresponding features in the intensity map component of the variance projection. The method of Shih notes that in this way, defects such as cracks, voids, delaminations, and dimensional differences will become apparent in the variance projection. For example, see paragraph [0035] of Shih.

In addition, Appellants note that at step 340, variant portions of the variance projection are identified. As clearly evidenced by paragraph [0037] of Shih, a variant portion is a region of the intensity map of the variance projection that includes some significant difference between the object projection and the standard projection. Shih further notes that the cause for the difference could be due to a defect or anomaly in the object. Furthermore, in some embodiments, once the variant portion has been identified it can be described in terms of its location within the intensity map of the variance projection. By way of example, a circular variant portion can be described by the location of the pixel at the center and a radius value. For example, see paragraphs [0037]-[0038] of Shih.

With continuing reference to the Shih reference, at step 350, a determination is made as to whether a sufficient number of variance projections have been generated to assess the quality of the object. For example, see paragraph [0039] of Shih. Moreover, if a sufficient number of variance projections has been generated to assess the quality of the object in step 350, then in step 360 the object is qualified. Shih further notes that qualification, in some embodiments, can include passing or failing the object. In other embodiments, qualification may comprise grading or segregating according to a particular metric. For example, see paragraph [0039] of Shih.

Appellants submit as described hereinabove, the variance projection of Shih is generated from the object and standard projections, where the variance projection is representative of the difference between the object and standard projections. Furthermore, the variance projection includes an intensity map and positional data from the perspective that is common to the standard and object projections.

Clearly, generating variance projections of the variations between the object and standard projections for particular perspectives as taught by Shih fails to supply the claimed recitation of <u>*generating a variance measure based on the measured projection data*</u> of the present application. Furthermore, based on the cited passages and associated observations in the Final Office Action and the Advisory Action, Appellants respectfully note that the Examiner has apparently equated "generating variance projections of the variations between the object and standard projections" of Shih with the "generation of variance measure based on the measured projection data" as claimed in the present application. Accordingly, Appellants respectfully reiterate that Shih *fails* to teach generation of variance measure based on the measured projection data as disclosed in the present application. In fact, as clearly evidenced at least by paragraph [0035] and claim 1 of Shih, the variance projection represents the difference between the object and stored standard projections. Particularly, any differences between the object and the stored standards create corresponding features in an intensity map (see Shih, paragraph [0035]). In sharp contrast, the variance measure, as

described in the present application, is solely based on the object, computed on a pixel-by-pixel basis and refers to measures of variation within various regions of pixels (for example, see paragraph [0034] and FIG. 4).

In light of the above, Appellants assert that the disclosure of "generating variance projections of the variations between the object and standard projections" of Shih may not be scientifically and meaningfully equated with the "generation of variance measure based on the measured projection data" of the present application.

Additionally, in the Office Action, the Examiner conceded that Shih fails to teach or suggest or disclose generating a variance map from the variance measure. The Examiner relied upon Liang to obviate the deficiencies of Shih. Particularly, the Examiner argued that Liang teaches treating noise in low-dose CT projections and reconstructed images. The Examiner noted that the method includes generating a curve for variance and means given a set of raw data, fitting the curve by a functional form, and determining, for a fitted curve, a transformed space having substantially constant variance for all means. Furthermore, the Examiner noted that the method also includes applying a domain specific filter in a sinogram domain of the set of raw data, and applying an EPS filter in an image domain of the set of raw data after filtering in the sonogram domain (citing the Abstract and FIGs. 5 and 9). The Examiner further argued that it would have been obvious to one of ordinary skill in the art to combine the generating a variance map as taught by Liang with the measured projection data using a reconstruction method in order to reduce radiation and that useful images are formed from these measured projection data since on would be motivated to make such modification to reduce artifacts thus improving image quality.

Appellants respectfully note that based on the cited passages and associated observations in the Office Action, the Examiner is apparently equating "generating a curve for variances" of Liang with the "generating a variance map from the variance measure using a reconstruction algorithm" as claimed in the present application. Appellants respectfully disagree. Particularly, Appellants submit that Liang is drawn to a method for

treating noise in low-dose computed tomography projections and reconstructed images. The method includes acquiring raw data at a low mA value, applying a domain specific filter in a sinogram domain of the raw data, and applying an edge preserving smoothing filter in an image domain of the raw data after filtering in the sinogram domain. Appellants submit that Liang merely discloses generating a curve for variance and mean values given a set of raw data, fitting the curve by a functional form, and determining, for a fitted curve, a transformed space having substantially constant variance for all mean values. The method further includes applying a domain specific filter in a sinogram domain of the set of raw data, and applying an EPS filter in an image domain of the set of raw data after filtering in the sinogram domain. (See Abstract, Figure 5 and Figure 9 of Liang).

Appellants respectfully state that although Liang generally alludes to the generation of a curve for variance and means, Liang fails to teach or suggest or disclose the cited claim element of generating a variance map from the variance measure using a reconstruction algorithm. Nowhere does Liang teach or suggest or disclose anything akin to generating a variance map from the variance measure using a reconstruction algorithm as disclosed in the present application. Moreover, Liang does not even mention the word "map" or anything analogous to that. Appellants respectfully emphasize that the claim element "variance map", as used in the present application, is very specifically described as a diagrammatical representation designed to visualize the regions of an image having similar variance due, for example, to one or more features or high density objects in the image (see page 10, paragraph [0034], lines 1-14). Therefore, Appellants assert that it may not be scientifically correct to equate a "variance map" as disclosed in the present application with a generic term such as a "curve for variances" as disclosed in Liang. Thus, Liang fails to supply the deficiencies of Shih.

For at least the reasons summarized hereinabove, Appellants submit that Shih and Liang, taken alone or in hypothetical combination, fail to disclose, teach or even suggest all elements of independent claims 12, 21, 28, 29 and 30. Hence, Shih even in combination with Liang fails to render claims 12, 21, 28, 29 and 30 obvious. Moreover, claims 13-20 are

depend directly or indirectly from claim 12. Accordingly, Appellants submit that claims 13-20 are allowable by virtue of their dependency from an allowable base claim, and for the subject matter they separately recite. Also, claims 22-27 depend directly or indirectly from claim 21. Accordingly, Appellants submit that claims 22-27 are allowable by virtue of their dependency from an allowable base claim, and for the subject matter they separately recite. Hence, it is respectfully requested that the rejection of claims 12-30 under 35 U.S.C. §103(a) be withdrawn.

Conclusion

Appellants respectfully submit that all pending claims are in condition for allowance. However, if the Examiner or Board wishes to resolve any other issues by way of a telephone conference, the Examiner or Board is kindly invited to contact the undersigned attorney at the telephone number indicated below.

Respectfully submitted,

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8. APPENDIX OF CLAIMS ON APPEAL

Listing of Claims:

12. A method for generating a variance map from measured projection data acquired from a tomography system comprising:

accessing the measured projection data from the tomography system;

formulating a variance measure based upon the measured projection data; and

generating the variance map from the variance measure using a reconstruction algorithm.

13. The method of claim 12, comprising determining variability of a mean pixel value caused by noise factors and artifact factors associated with the measured projection data based upon the variance measure.

14. The method of claim 12, wherein formulating a variance measure is based on a statistical model.

15. The method of claim 12, wherein the reconstruction algorithm is a weighted filtered backprojection reconstruction algorithm.

16. The method of claim 12, wherein the reconstruction algorithm is a fast reconstruction algorithm such as a Fourier-based algorithm, a hierarchical algorithm, or a coarse reconstruction based on downsampled projection data and/or image data.

17. The method of claim 15, wherein the reconstruction algorithm is adapted to operate on the variance measure to generate the variance map.

18. The method of claim 12 further comprises displaying, analyzing or processing the variance map.

19. The method of claim 12, wherein the measured projection data is reconstructed to generate original image data and wherein the original image data is displayed or analyzed based upon or in conjunction with the variance map.

20. The method of claim 12, further comprising identifying features of interest in the original image data based upon the variance map.

21. A method for generating a variance map from measured projection data acquired from a tomography system comprising:

accessing the measured projection data from the tomography system;

formulating a variance measure based upon the measured projection data;

generating the variance map based upon the variance measure using a reconstruction algorithm; and

displaying, analyzing or processing the variance map.

22. The method of claim 21, comprising determining variability of a mean pixel value caused by noise factors and artifact factors associated with the measured projection data based upon the variance measure.

23. The method of claim 21, wherein formulating a variance is based upon a statistical model.

24. The method of claim 21, wherein the reconstruction algorithm is a weighted filtered backprojection reconstruction algorithm.

25. The method of claim 24, wherein the reconstruction algorithm is adapted to operate on the variance measure to generate the variance map.

26. The method of claim 21, wherein the measured projection data is reconstructed to generate original image data and wherein the original image data is displayed, analyzed or processed based upon the variance map.

27. The method of claim 21, further comprising identifying features of interest in the original image data based upon the variance map.

28. A tomography system for generating a variance map from measured projection data comprising:

an X-ray source configured to project a plurality of X-ray beams through an object;

a detector configured to produce a plurality of electrical signals in response to received X-ray beams from the source; and

a processor configured to process the plurality of electrical signals to generate measured projection data, wherein the processor is further configured to access the

measured projection data from the tomography system; to formulate a variance measure based upon the measured projection data; to generate a variance map based upon the variance measure using a reconstruction algorithm; and to display, analyze or process the variance map.

29. At least one non-transitory computer-readable medium storing computer instructions for instructing a computer system for generating a variance map from projection data acquired from a tomography system, the computer instructions comprising:

accessing the projection data from the tomography system;

generating a variance map from the projection data; and

displaying, analyzing or processing the variance map.

30. A tomography system for generating a variance map from measured projection data comprising:

means for accessing the measured projection data from the tomography system;

means for formulating a variance measure based upon the measured projection data;

means for generating the variance map based upon the variance measure using a reconstruction algorithm; and

means for displaying analyzing or processing the variance map.

9. APPENDIX OF EVIDENCE

None.

10. APPENDIX OF RELATED PROCEEDINGS

None.